[redacted]

Copy 3
RM L58E13

NACA RM L58E13

c.1

RESEARCH MEMORANDUM

HYDRODYNAMIC CHARACTERISTICS OF A MODEL OF A PROPOSED SIX-ENGINE HULL-TYPE SEAPLANE DESIGNED FOR SUPERSONIC FLIGHT

By Claude W. Coffee, Jr.

Langley Aeronautical Laboratory
Langley Field, Va.

NASA ccN 113
2-28-67
kmp
7-31-67

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON
July 14, 1958

[redacted]

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

HYDRODYNAMIC CHARACTERISTICS OF A MODEL OF A PROPOSED SIX-ENGINE HULL-TYPE SEAPLANE DESIGNED FOR SUPERSONIC FLIGHT*

By Claude W. Coffee, Jr.

SUMMARY

An investigation was made of the hydrodynamic characteristics of a six-engine hull-type seaplane designed for supersonic flight. This configuration had four engines mounted on top of the wing in individual nacelles and two engines mounted on top of the aft section of the hull with their inlets located on top of the wing. The tests indicated that excess thrust was available for take-off in approximately 25 seconds and 3,250 feet (full size). Stable take-offs could be made over a small range of fixed stabilizer deflections. The deflected flaps dragged in the water at speeds less than 104 knots. During landings the flaps should be retracted as soon as possible after contact to prevent damage to the deflected flaps by spray. Heavy spray entered the inlets of the outboard nacelles over a short speed range in both smooth and rough water. The inlets of the inboard nacelles were clear of spray in smooth water but would probably be wet in waves 4 feet high and greater when the bow digs into an oncoming wave. The high horizontal tail was generally clear of spray.

INTRODUCTION

The present investigation is part of a general research program to evaluate the aerodynamic and hydrodynamic characteristics of water-based aircraft configurations capable of flight at transonic and supersonic speeds. These configurations have been characterized by high fineness ratio and small frontal area and have conformed to the area-rule concept (refs. 1, 2, and 3). Aerodynamic tests (refs. 4, 5, and 6) have indicated low subsonic drag, high drag-rise Mach number, and low drag-rise increment. The hydrodynamic performance (refs. 4 to 8) has been acceptable.

*Title, Unclassified.

[redacted]

The previous configurations have embodied the use of four engines, and the various arrangements of the nacelles and/or internal ducting have offered a variety of design possibilities. In cooperation with the Bureau of Aeronautics, Department of the Navy, and the aircraft industry, a six-engine configuration was evolved which was designed for a sustained cruise Mach number of 1.8 at altitude. In this configuration, four engines were mounted in individual nacelles on the upper surface of the wing. A staggered arrangement of these nacelles was dictated by area-rule considerations. The two remaining engines were placed side by side on top of the aft section of the hull with their inlets being located on top of the wing.

A hydrodynamic investigation of this configuration was made in the Langley tank no. 1 to determine the smooth-water resistance, spray characteristics, and the landing and take-off stability. A brief investigation also was made of the spray characteristics during taxiing in rough water.

SYMBOLS

A.P.	after perpendicular
b	hull beam, ft
c	wing chord, ft
$\bar{c}$	mean aerodynamic chord, ft
C_L	aerodynamic lift coefficient, $\frac{L}{\frac{1}{2}\rho SV^2}$
C_m	aerodynamic pitching-moment coefficient, $\frac{M}{\frac{1}{2}\rho SV^2\bar{c}}$
C_{Δ_o}	gross-load coefficient, $\frac{\Delta_o}{wb^3}$
F.P.	forward perpendicular (hull station 0)
L	lift, lb
L.W.L.	load water line

M — pitching moment about center of gravity, positive nose upward, lb-ft

S — wing area, sq ft

V — speed, ft/sec

w — specific weight of water, 63.3 lb/cu ft for these tests

δ_e — elevator deflection referred to stabilizer chord, positive when trailing edge is down, deg

δ_f — flap deflection, positive downward, deg

δ_s — stabilizer deflection referred to hull base line, positive when trailing edge is down, deg

Δ_o — gross load, lb

ρ — air density, slugs/cu ft

DESCRIPTION OF CONFIGURATION

A general arrangement drawing and hull layout are presented in figures 1 and 2, respectively. Pertinent dimensions and particulars are given in table I.

General Characteristics

For the proposed water-based aircraft, a gross load of 220,000 pounds and a wing area of 1,835 square feet were assumed. Six Orenda Iroquois PS-13 turbojet engines, producing a maximum static thrust of 120,000 pounds without afterburners, were selected.

Engine location.- The four engines, which were located in individual nacelles on top of the wing, were staggered so that the two inboard nacelles were forward of the wing and the two outboard nacelles were directly over the wing (see fig. 1). The two remaining engines, which were located side by side in the after section of the hull, had their inlet located on top of the wing near the 50-percent-chord line.

Wing.- The wing embodied a 3.5-percent-thick biconvex airfoil section. The maximum thickness was located at the 50-percent-chord line. The taper ratio was 0.33, the aspect ratio was 3, the sweepback was 0 at the 80-percent-chord line, and the wing incidence was 3°. Full-span trailing-edge flaps were incorporated.

Planing bottom.- The planing surfaces extended over approximately 94 percent of the fuselage total length. The forebody length-beam ratio was 7.62 and the afterbody length-beam ratio was 6.33. The maximum beam at the chines was 9.2 feet.

The forebody cross sections were rounded at the keel to approximate the constant-force bottoms described in references 9 and 10. The concave-convex shape of the forebody is shown in figure 2. The plan form of the step was approximately a 60° vee. A full-step fairing reduced the depth of step to zero.

Horizontal chine flare was used on the forebody from approximately 8 feet aft of the forward perpendicular to the step. The chine flare on the afterbody extended from approximately 11 feet aft of the point of the step to the after perpendicular. The dead rise at the after perpendicular was 55°.

Tail group.- The horizontal tail was mounted on top of the vertical tail. The high position was considered necessary for clearance of spray generated by the heavily loaded hull.

Tip floats.- Tip floats are generally necessary to provide static transverse stability on the water. The tip floats of this configuration were bodies of revolution that provided approximately 60 percent of the volume necessary to achieve the required static transverse stability (ref. 11). An auxiliary device, such as an inflatable bag, would be necessary to provide for the remaining 40 percent of the volume required.

Area Curves

The total cross-sectional area curves for Mach numbers of 1.8 and 1.0 and the contributions of the various components are presented in figure 3. The contributions of area of the tail group and the tip floats are not included. An equivalent free-stream tube area of 80 percent of the inlet area was subtracted for the mass flow through the ducts.

The maximum total cross-sectional area at the design Mach number (1.8) was 135 square feet and the fineness ratio of the equivalent body of revolution was 10.2. The staggered arrangement of the nacelles provided a smooth longitudinal cross-sectional area distribution with a minimum of fuselage indentation.

For comparison, the cross-sectional area distribution at a Mach number of 1.0 is provided. At a Mach number of 1.0, the maximum total cross-sectional area was increased to 157.5 square feet and the fineness ratio of the equivalent body of revolution was decreased to 9.5.

Tank Model

Photographs of the 1/19-size dynamic model are presented in figure 4. The hull was constructed of plastic-impregnated fiber glass and the aerodynamic surfaces were of wood covered with plastic-impregnated fiber glass.

Leading-edge slats were attached to the wing in order to delay the stall to an angle of attack more nearly equal to that of the full-size seaplane. The full-span trailing-edge flaps had a maximum deflection of 45°.

The stabilizer deflection could be varied during the test runs from 5° to -15° and the elevator deflection could be fixed at angles from 25° to -25°.

Electric contacts located on the keel at the bow, step, and sternpost indicated when these portions of the hull were in contact with the water and were used to release the trim brake during landing tests.

The center of gravity was located at $0.31\bar{c}$ for all tests. The pitching moment of inertia of the ballasted model was 2.15 slug-sq ft (model size) corresponding to 5,320,000 slug-sq ft (full size).

APPARATUS AND PROCEDURE

The tests were made in Langley tank no. 1, which is described in reference 12. The apparatus and procedure generally used for testing dynamic models are described in reference 13 and are similar to those used for the investigations described in reference 4.

The aerodynamic lift and pitching moment were determined at the normal center-of-gravity position. During these tests, the model height above the water was adjusted so that the lowest point of the model was just clear of the water surface at each trim.

All hydrodynamic tests were made at a gross load corresponding to 220,000 pounds full size, except the landings which were made at two gross loads (220,000 and 192,000 pounds, full size). For the smooth-water tests, the model was pivoted at the center of gravity and had freedom in only trim and rise. A photograph of the model on the smooth-water towing gear is shown in figure 5. For the rough-water tests, the model had approximately 5 feet of fore-and-aft freedom in addition to freedom in trim and rise. For tests with fixed stabilizer and elevator settings, the elevator deflection was twice the stabilizer deflection. The thrust moment of the six engines was simulated by a weight moment and was applied during all hydrodynamic tests except the landing tests.

Slide-wire pickups were used to obtain records of the trim, rise, and fore-and-aft location. Trim was the angle between the forebody keel at the step and the undisturbed water surface. Positive trims are bow-up. Rise of the center of gravity was set at zero with the step touching the water surface with the hull at zero trim. Positive rise of the center of gravity is upward.

The resistance of the complete model, including air drag, was determined for a range of constant speeds. A flap deflection of 0° was used up to a speed of approximately 155 knots, which corresponds to the take-off speed with 45° flap deflection and 6.5° trim. Data with flaps deflected 45° were obtained from a speed of approximately 100 knots to take-off. The air drag of the towing staff was subtracted as a tare from the total resistance. Photographs and spray observations were made during these runs.

The trim limits of stability were determined during constant-speed runs. At each speed, the trim of the model was changed by adjusting the horizontal tail deflection until porpoising was noted or until the maximum up or down aerodynamic tail moment was obtained. The trim at which porpoising was first observed was taken as the stability limit.

Take-offs were simulated using an average rate of acceleration of 3 ft/sec^2. Data were taken with zero flap deflection up to a speed of approximately 155 knots and with full flaps from approximately 100 knots to take-off. Take-offs were made with fixed stabilizer and elevator deflection and fixed thrust moment.

Landings were made with full-flap deflection for a range of contact trims. The landing runout was terminated at approximately 90 knots to prevent possible damage to the deflected flaps. With the model at the desired landing trim, the carriage was decelerated at a uniform rate, allowing the model to glide onto the water. The model was held at the desired landing trim by the trim brake until contact with the water surface. The static thrust moment was not used during the landing tests because of the simulated power-off condition.

Spray characteristics in waves were determined during accelerated taxi tests (rate of acceleration, 3 ft/sec^2). The wave heights tested were 2, 4, and 5 feet and the lengths were 285 and 570 feet. Because the model was not powered, the horizontal thrust component was simulated by a rubber-band arrangement described in reference 14. The low-spring constant of the rubber band allowed the model to check in waves without introducing large changes in the horizontal force.

RESULTS AND DISCUSSION

All data as presented correspond to full-size values.

Aerodynamic

The aerodynamic lift and pitching-moment coefficients are plotted against trim in figure 6. The computed thrust moment, which was simulated during hydrodynamic tests, is also shown.

Hydrodynamic

Spray characteristics for smooth water.- Typical bow and stern photographs of the smooth-water spray with zero flap deflection and with 45° flap deflection are shown in figures 7 and 8, respectively. The inlets of the inboard nacelles, which are located forward of the wing, were clear of spray throughout the speed range. The inlets of the outboard nacelles are located near the wing leading edge and they were struck by heavy spray from the forebody over a short speed range, approximately 36 to 44 knots (fig. 7).

At this speed range (36 to 44 knots), the bow blister was sufficiently high to wet the upper surface of the wing outboard of the inboard nacelle. The undersurface of the wing with zero flap deflection was struck by spray throughout most of the speed range investigated. The flaps were not deflected until a speed of approximately 104 knots because below this speed they dragged in the water. The flaps when deflected 45° were heavily wetted by spray at all trims up to a speed of approximately 116 knots. This wetting of the flaps appeared to cause oscillations in trim and rise. At speeds above 116 knots, the flaps were wet when the trim exceeded 6° (fig. 8).

With both flap settings, the forebody wake attached to the afterbody under certain combinations of trim and speed. With zero flap deflection, the model trimmed up and oscillated in trim and rise when flow attached to the sides of the afterbody. With the flaps deflected 45°, the model trimmed up when the flow attached to the sides of the afterbody.

If the flow attached only to the afterbody bottom, there was no change in trim.

The high horizontal tail was clear of spray except during rise and trim oscillations at high speeds, during which the tail was struck by very light spray.

Spray characteristics for rough water.- During rough-water taxiing, the inlets of the outboard nacelles and the upper surface of the wing were wetted by very heavy spray in all wave heights tested. The inboard nacelles appeared to be clear of spray until the bow of the model dug into an oncoming wave (wave heights 4 feet and greater); spray was then thrown up a short distance forward of the inlet. If the model had been powered, this spray would probably have been drawn into the inlet. The undersurface of the wing was heavily wetted during the taxiing tests.

Resistance.- The total resistance and the corresponding trim and rise are presented in figure 9 for 0° and 45° flap deflection and several positions of the stabilizer and elevators. The total resistance is plotted for stable trims only. With zero flap deflection, the resistance increased with speed to approximately 55 knots; at this speed a minimum gross-load—total-resistance ratio of 3.2 was obtained. With further increase in speed, the resistance decreased as the model entered the planing region.

As was expected when the flaps were deflected 45° at a speed of approximately 100 knots, the resistance increased. Part of this increase in resistance was apparently the result of heavy wetting of the deflected flaps by spray. Because of this increase in resistance, full-flap deflection appeared to be of little advantage until near take-off speed. When flow attached to the sides of the afterbody, there was a large increase in resistance apparently caused by the heavy wetting of the afterbody sides and bottom. When the flow attached to only the afterbody bottom (stabilizer deflection, -2.5°, and flap deflection, 45°), there was a small increase in resistance.

Excess thrust was available for acceleration throughout the speed range. The computed take-off time and distance, assuming deflection of the flaps at approximately 140 knots, corresponded to 25 seconds and 3,250 feet (full size).

Trim limits of stability.- The trim limits of stability are presented in figure 10 for the two flap settings. During the constant-speed runs when the forebody wake attached to the sides of the afterbody, the model trimmed up without a change in the stabilizer setting. When the upper limit, increasing trim, was encountered, the trim and rise oscillations were erratic. The porpoising cycles appeared to be affected by flow alternately sticking to and breaking clear of the afterbody during the oscillations.

At speeds greater than approximately 105 knots and with zero flap deflection, the model porpoised violently between the upper and lower limits after the upper limit, increasing trim, was encountered. This porpoising could not be stopped by the use of the stabilizer and the porpoising cycles continued to increase in amplitude. With the flaps deflected 45°, the upper limit, decreasing trim, over a range of speed from 110 to 130 knots, could not be defined because of large changes in trim that occurred when the attached afterbody flow was broken.

The lower limit with zero flap deflection was similar to that encountered with other water-based aircraft. As would be expected, deflection of the flaps decreased the trim at which the lower limit was encountered. Only one point on the lower limit (45° flap deflection) was obtained because the deflected flaps were dragging in the water at speeds less than approximately 104 knots and at higher speeds trims less than 1° were encountered.

Take-off stability.- The variations in trim and rise with speed during accelerated runs at various fixed stabilizer and elevator positions are shown in figure 11 for the two flap deflections. The accelerated runs with zero flap deflection were made up to a speed of approximately 155 knots in order that the lower resistance associated with the zero-flap-deflection condition could be utilized. The trimming moment of the stabilizer (zero flap deflection) was sufficient to provide a wide range of stable trims at speeds greater than hump speed (approximately 70 knots). Lower-limit porpoising was encountered with a stabilizer deflection of 2.5° (zero flap deflection) and the model trimmed up into the upper limit after flow attached to the afterbody with a stabilizer deflection of -3.5° (zero flap deflection). A range of fixed stabilizer deflections between 2.5° and -3.5° was available for stable accelerated runs to approximately 155 knots.

Heavy wetting of the deflected flaps (45°) up to a speed of approximately 116 knots caused the model to oscillate during the accelerated runs. With a stabilizer deflection of -3.5°, this oscillation persisted throughout the take-off run. At higher stabilizer deflections, the oscillations damped out rapidly as speed was increased. When flow attached to the afterbody, the expected sudden increase in trim occurred, and at a stabilizer setting of -6.5°, the model trimmed into the upper limit and porpoised violently during the remainder of the take-off run. With 45° flap deflection, a range of fixed stabilizer deflections between -3.5° and -6.5° was available for stable take-offs.

Landing stability.- The variations in trim and rise during typical landing runouts with 45° flap deflection are shown in figure 12 for two gross loads (220,000 and 192,000 pounds). The maximum variation in trim and rise and the number of skips are presented in figure 13 for the two gross loads and 45° flap deflection. Oscillations in trim and rise occurred during the landing runout. These oscillations did not appear to be violent but the deflected flaps on the full-size seaplane should probably be retracted as soon as possible after contact to prevent damage to the deflected flaps by spray. For both gross loads, the model skipped once on landing at trims less than the sternpost angle (7.5°). The skips were not violent and generally occurred with small changes in trim and rise. When landing at trims greater than the sternpost angle, the model generally trimmed down against the lower trim stop (set at approximately 1.6°).

CONCLUDING REMARKS

The hydrodynamic characteristics of a six-engine hull-type seaplane designed for supersonic flight have been investigated. The results indicated that excess thrust was available for acceleration to take-off in approximately 25 seconds and 3,250 feet. At a speed of approximately 55 knots, a minimum gross-load—total-resistance ratio of 3.2 was obtained. A small range of stabilizer deflections was available for stable take-offs. The deflected flaps dragged in the water at speeds less than 104 knots. The flaps should be retracted as soon after the landing as possible to prevent damage to the deflected flaps by spray. The inlets of the outboard nacelles were struck by heavy spray over a short speed range in smooth and rough water. The inlets of the inboard nacelles were clear of spray in smooth water but would probably be wet in waves 4 feet high and greater when the bow digs into an oncoming wave. The horizontal tail was struck by very light spray during trim and rise oscillations at high speeds.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., April 21, 1958.

REFERENCES

1. Whitcomb, Richard T.: A Study of the Zero-Lift Drag-Rise Characteristics of Wing-Body Combinations Near the Speed of Sound. NACA Rep. 1273, 1956. (Supersedes NACA RM L52H08.)

2. Whitcomb, Richard T., and Fischetti, Thomas L.: Development of a Supersonic Area Rule and an Application to the Design of a Wing-Body Combination Having High Lift-to-Drag Ratios. NACA RM L53H31a, 1953.

3. Whitcomb, Richard T.: Some Considerations Regarding the Application of the Supersonic Area Rule to the Design of Airplane Fuselages. NACA RM L56E23a, 1956.

4. Olson, Roland E., and Bielat, Ralph P.: An Aerodynamic and Hydrodynamic Investigation of Two Multijet Water-Based Aircraft Having Low Transonic Drag Rise. NACA RM L55A11a, 1955.

5. Bielat, Ralph P., Coffee, Claude W., Jr., and Petynia, William W.: Aerodynamic and Hydrodynamic Characteristics of a Deck-Inlet Multijet Water-Based-Aircraft Configuration Designed for Supersonic Flight. NACA RM L56H01, 1956.

6. Petynia, William W., Hasson, Dennis F., and Spooner, Stanley H.: Aerodynamic and Hydrodynamic Characteristics of a Proposed Supersonic Multijet Water-Based Hydro-Ski Aircraft With a Variable-Incidence Wing. NACA RM L57G05, 1957.

7. McKann, Robert E., and Coffee, Claude W.: Limited Hydrodynamic Investigation of a 1/15-Size Model of a Modified Nose-Inlet Multijet Water-Based Aircraft. NACA RM L55J19, 1956.

8. Blanchard, Ulysse J.: Hydrodynamic Investigation of a Model of a Supersonic Multijet Water-Based Aircraft With Engines Exhausting From the Step. NACA RM L57F20, 1957.

9. Wagner, Herbert: Landing of Seaplanes. NACA TM 622, 1931.

10. Bisplinghoff, R. L., and Doherty, C. S.: A Two-Dimensional Study of the Impact of Wedges on a Water Surface. Contract No. NOa(s)-9921, Dept. Aero. Eng., M.I.T., Mar. 20, 1950.

11. Anon.: Specification for Transverse Stability of Seaplanes. Displacement and Location of Auxiliary Floats. NAVAER SR-59C (superseding SR-59B), Bur. Aero., Feb. 20, 1942.

12. Truscott, Starr: The Enlarged N.A.C.A. Tank, and Some of Its Works. NACA TM 918, 1939.

13. Olson, Roland E., and Land, Norman S.: Methods Used in the NACA Tank for the Investigation of the Longitudinal-Stability Characteristics of Models of Flying Boats. NACA Rep. 753, 1943. (Supersedes NACA WR L-409.)

14. Mottard, Elmo J.: A Brief Investigation of the Effect of Waves on the Take-Off Resistance of a Seaplane. NACA RM L56B09, 1956.

TABLE I.- PERTINENT CHARACTERISTICS AND DIMENSIONS OF THE FULL-SIZE WATER-BASED AIRCRAFT

General:	
Gross weight, lb	220,000
Wing area, sq ft	1,835
Engines, Orenda Iroquois PS-13	6
Take-off thrust (without afterburners), lb	120,000
Wing loading, lb/sq ft	120
Take-off thrust-weight ratio	0.545
Wing:	
Span, ft	74.15
Airfoil section	Biconvex
Thickness, percent chord	3.5
Aspect ratio	3.0
Taper ratio	0.333
Sweepback (0.80c), deg	0
Length, mean aerodynamic chord, ft	22.7
Forward perpendicular to leading edge of $\bar{c}$, ft	60.08
Incidence, deg	3
Horizontal tail:	
Span, ft	32.7
Airfoil section	Biconvex
Thickness, percent chord	3.5
Area, sq ft	355
Aspect ratio	3.0
Taper ratio	0.4
Sweepback (0.80c), deg	0
Dihedral, deg	15
Arm, length between $0.31\bar{c}$, ft	65.59
Vertical tail:	
Airfoil section	NACA 63A005
Area, sq ft	230
Aspect ratio	1.0
Sweepback (0.25c), deg	50
Hull:	
Forebody length (forward perpendicular to step centroid), ft	70.08
Afterbody length (step centroid to after perpendicular), ft	58.25
Length, overall, ft	134.09
Beam at chines, maximum, ft	9.2
Width, maximum, ft	10
Height, maximum, ft	16.25
Step plan form (basic)	60° Vee
Dead rise at after perpendicular, deg	55
Afterbody keel angle, deg	6.5
Sternpost angle, deg	7.5
Center of gravity, $0.31\bar{c}$	
Above base line, ft	8.3
Forward of step centroid, ft	2
Step centroid to $0.31\bar{c}$, angle to vertical, deg	13.5
Forebody length-beam ratio, $\frac{L_f}{b_{max}}$	7.62
Afterbody length-beam ratio, $\frac{L_a}{b_{max}}$	6.33
Total length-beam ratio, $\frac{(L_f + L_a)}{b_{max}}$	13.95
C_{Δ_o}	4.42
Area curves:	
Mach number, 1.0	
Maximum cross-sectional area, sq ft	157.5
Maximum diameter of equivalent body, ft	14.2
Length, ft	134.1
Fineness ratio of equivalent body	9.5
Mach number, 1.8	
Maximum cross-sectional area, sq ft	135.0
Maximum diameter of equivalent body, ft	13.1
Length, ft	134.1
Fineness ratio of equivalent body	10.2

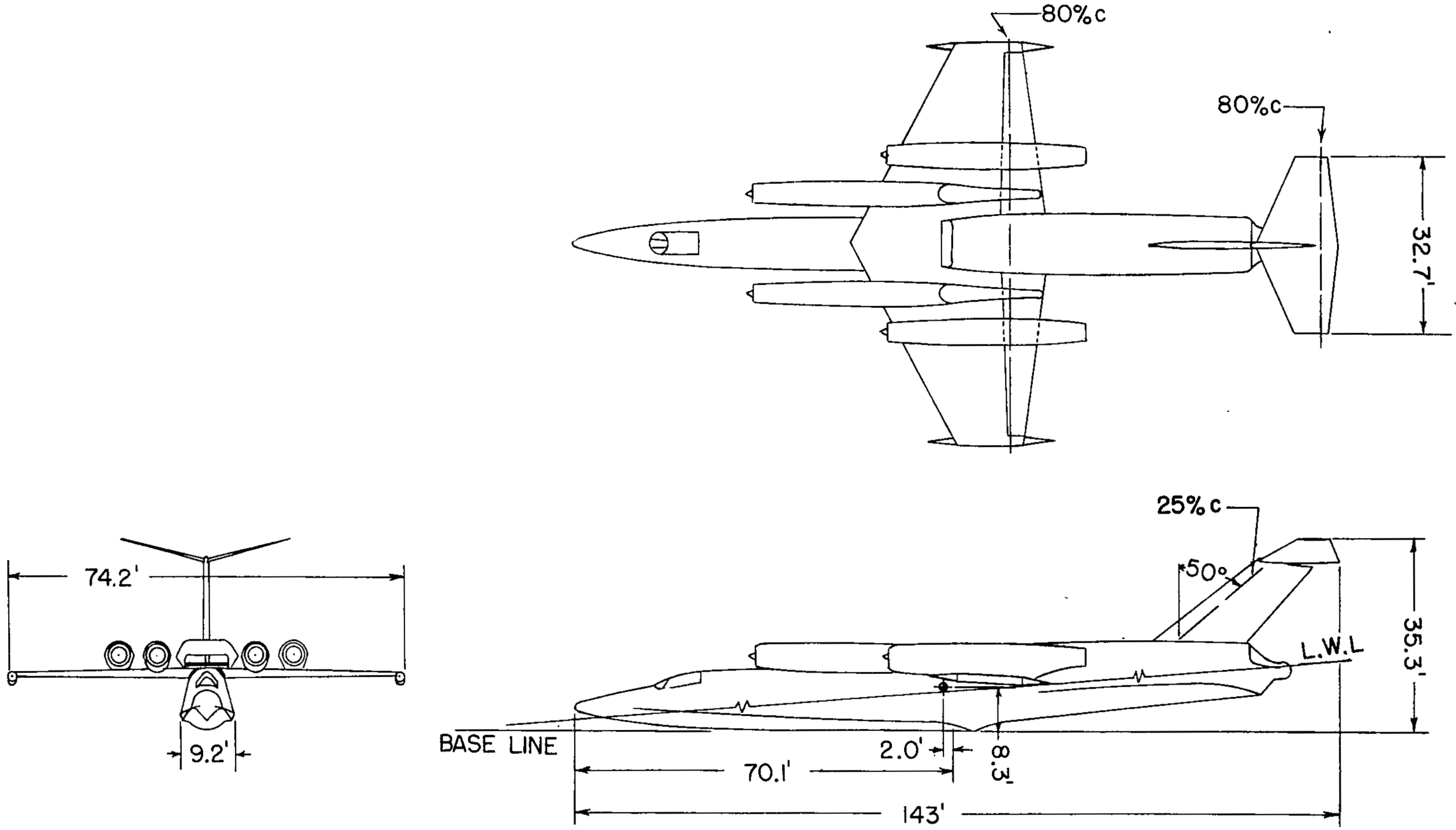


Figure 1.- General arrangement of configuration.

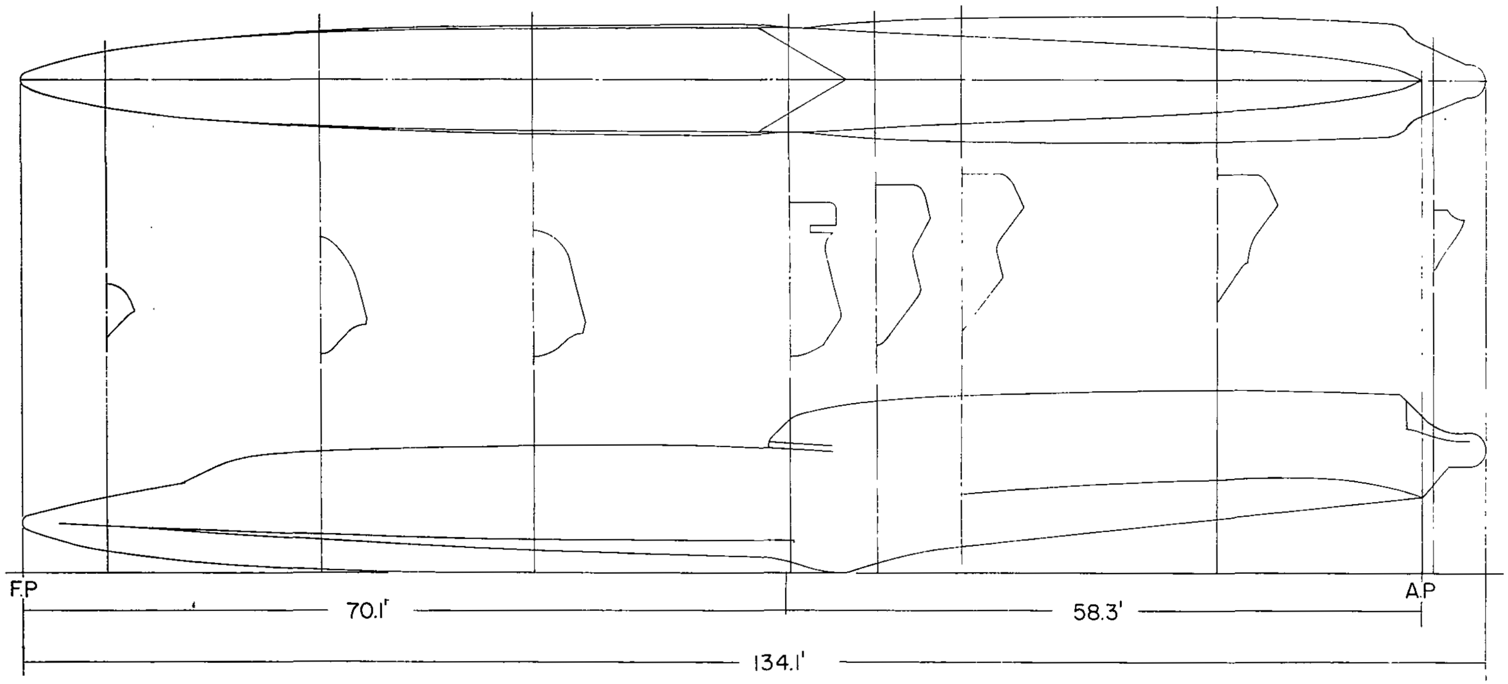
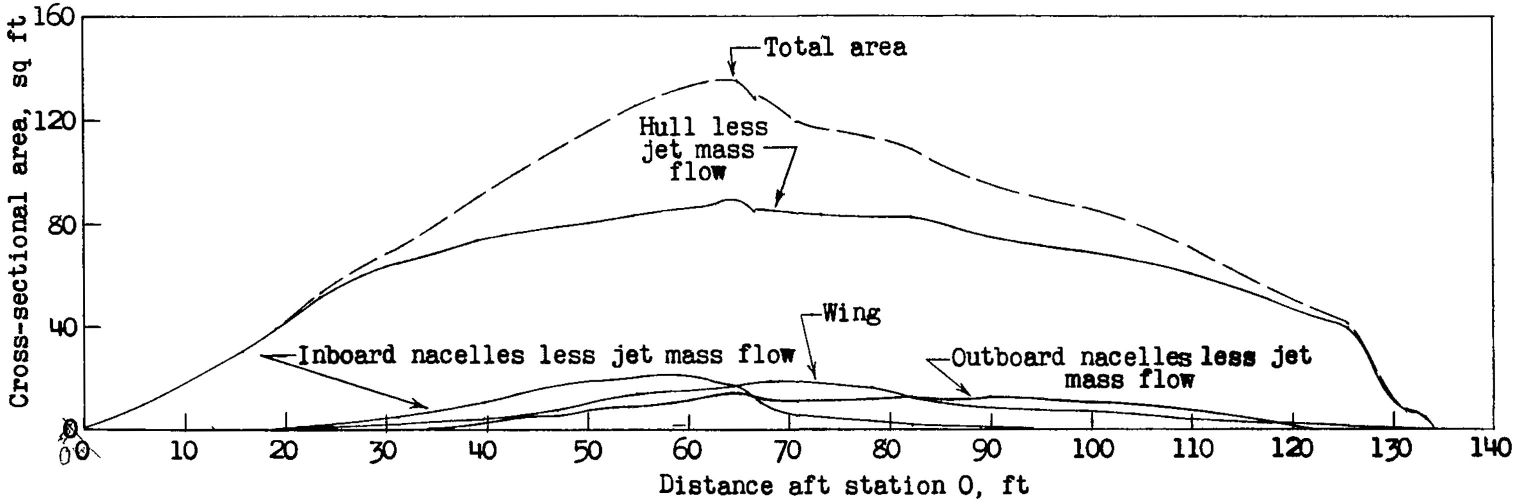
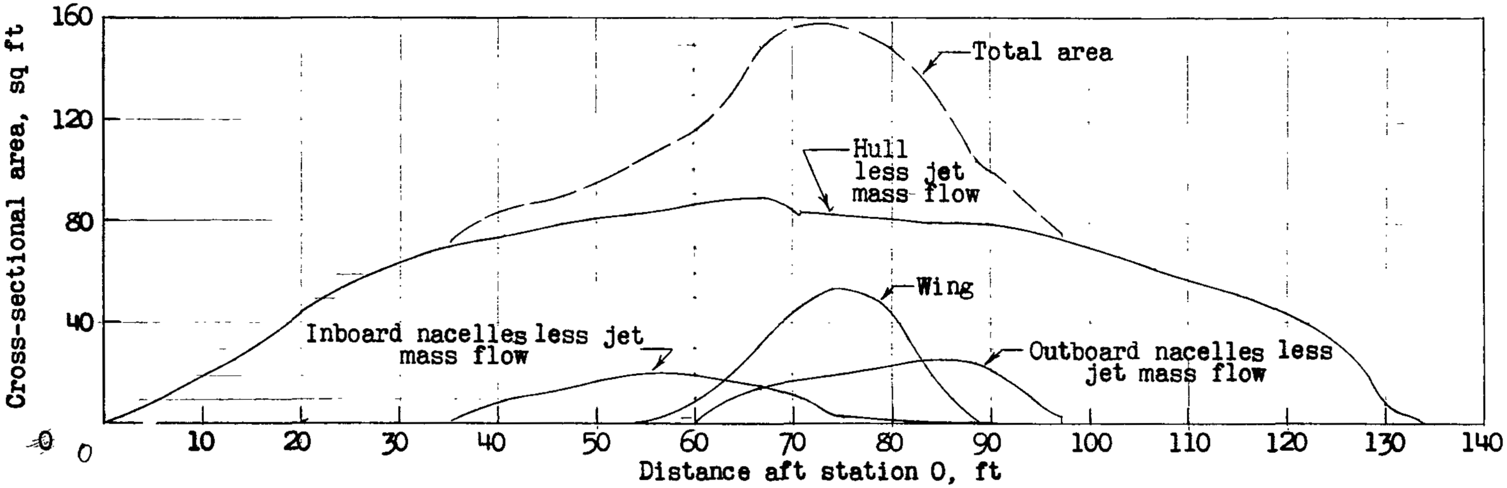


Figure 2.- Layout of hull lines.



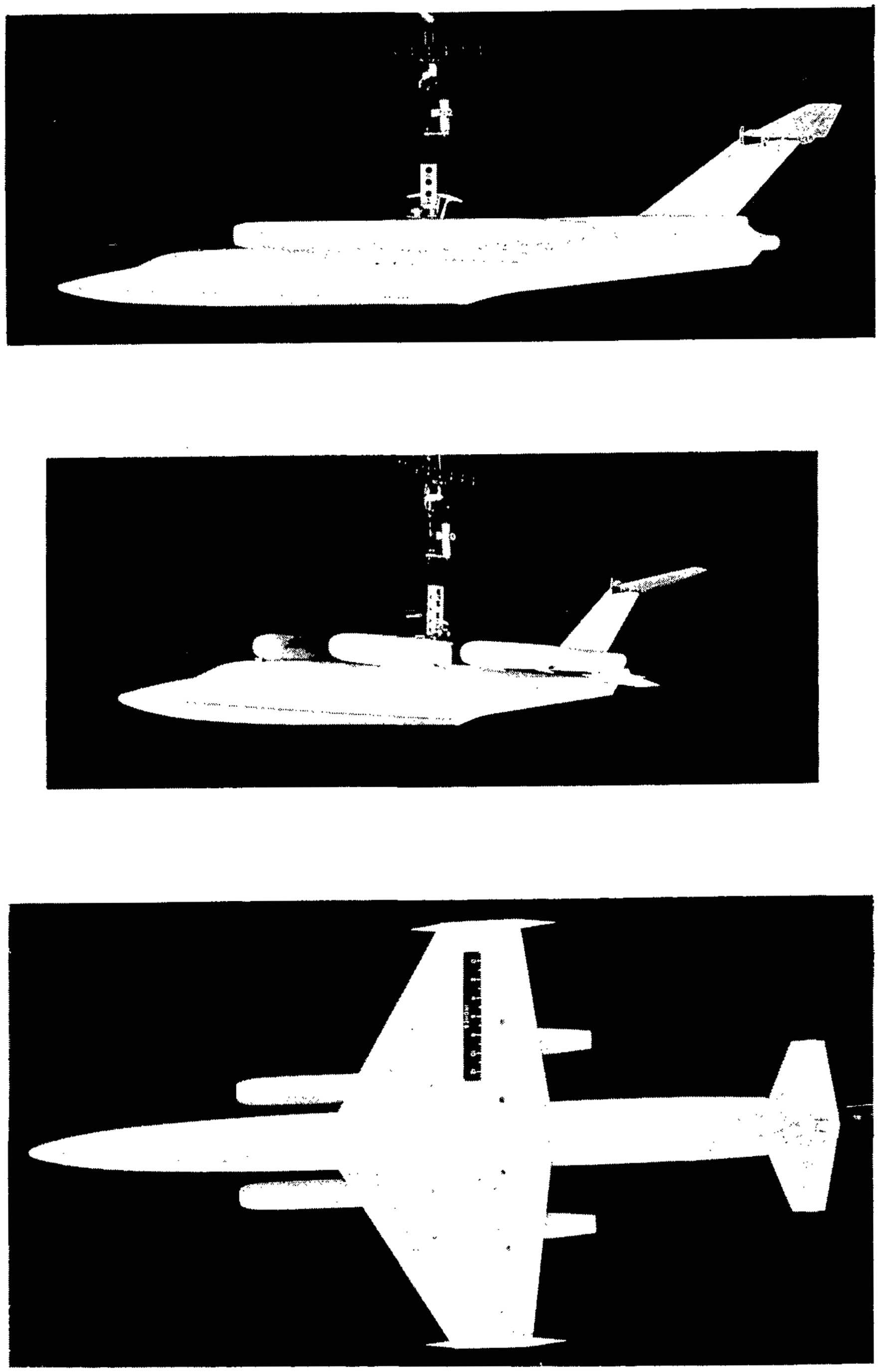
(a) Mach number, 1.8.

Figure 3.- Cross-sectional area curves.



(b) Mach number, 1.0.

Figure 3.- Concluded.



L-58-1657

Figure 4.- Photographs of the 1/19-size model tested in Langley tank no. 1.

[redacted]

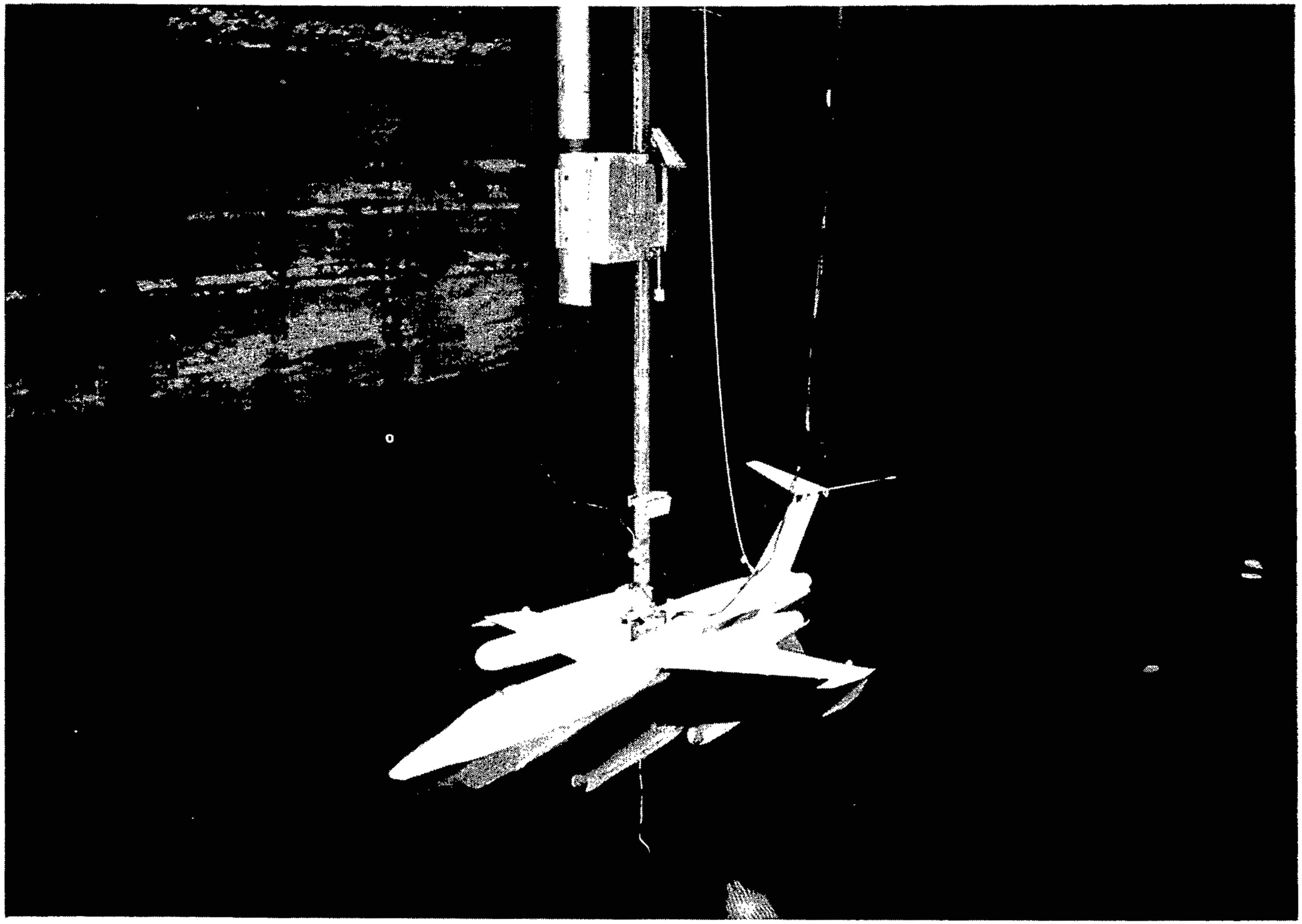


Figure 5.- Setup of model on the smooth-water towing gear. L-58-1658

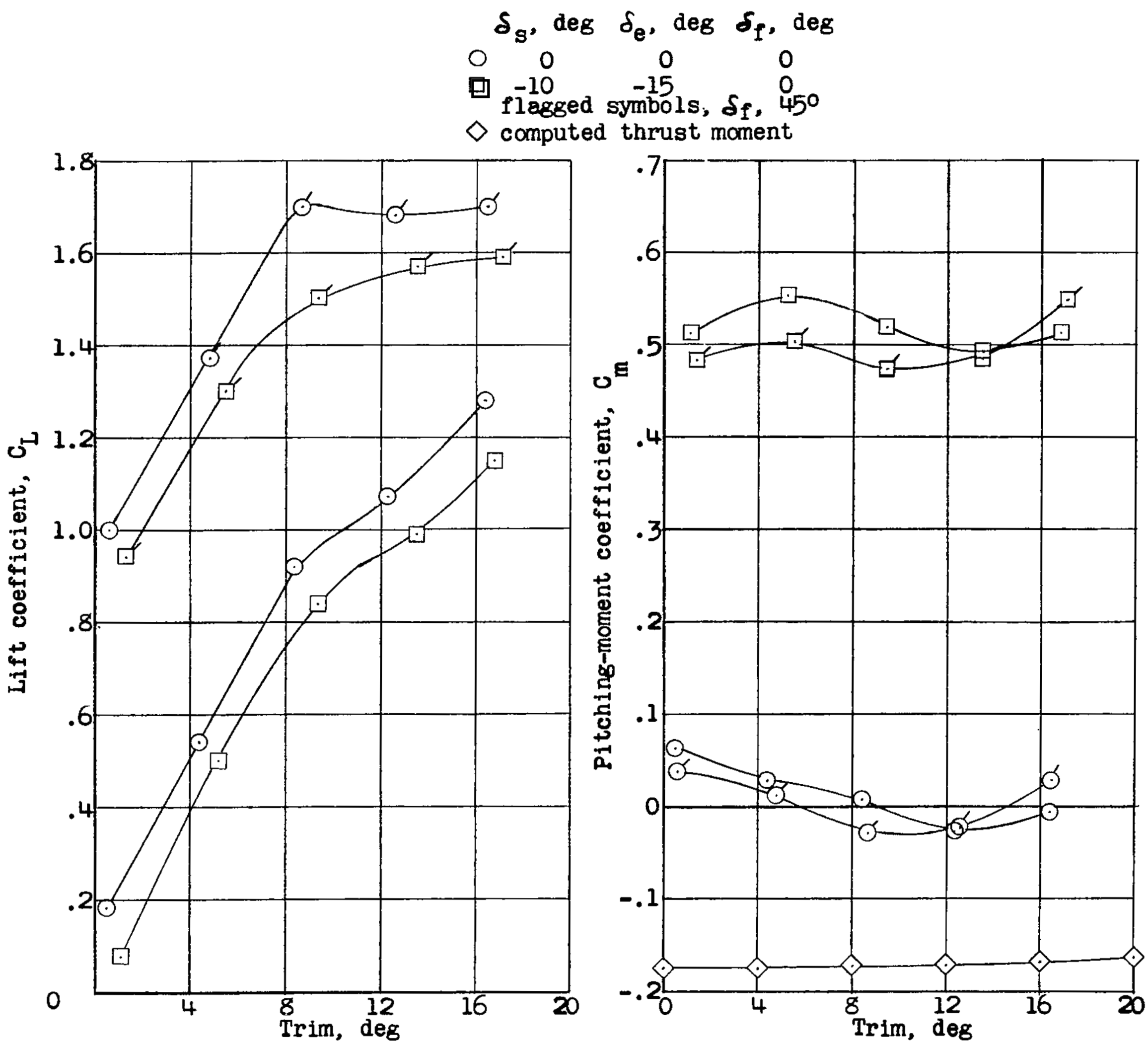
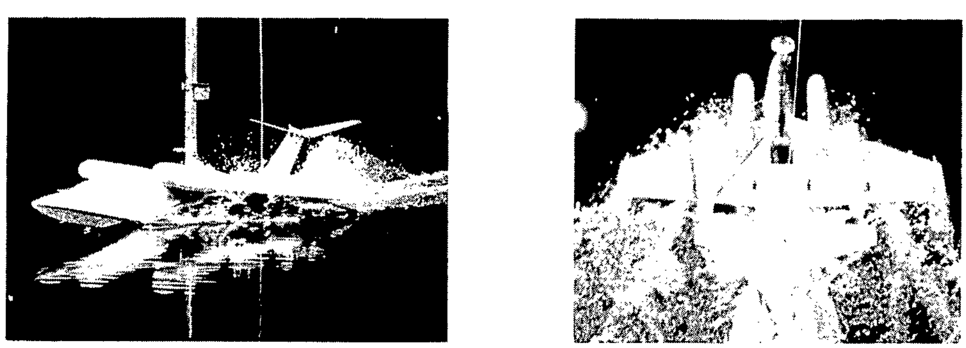


Figure 6.- Variation in aerodynamic lift and pitching-moment coefficient with trim for the 1/19-size model.

Trim, 3.8°; speed, 10.6 knots.

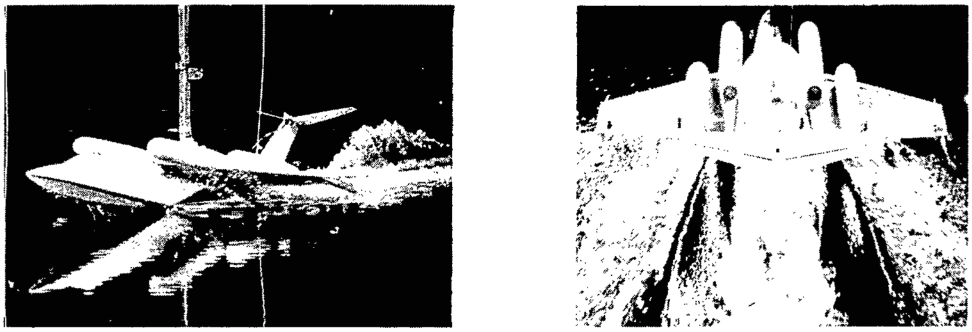
Trim, 5.2°; speed, 20.9 knots.



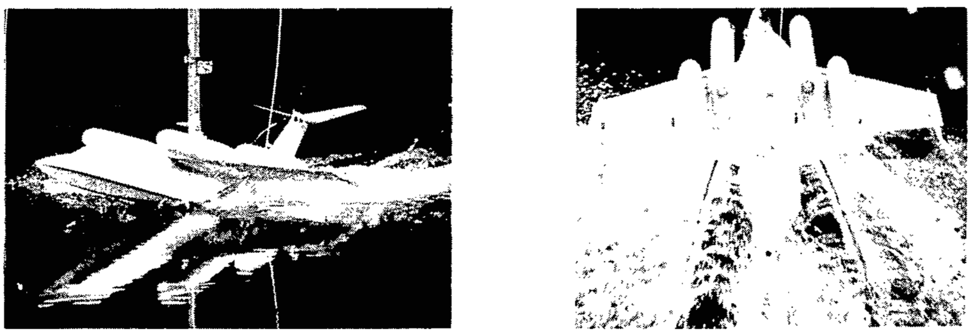
Trim, 6.8°; speed, 38.7 knots.

L-58-1659

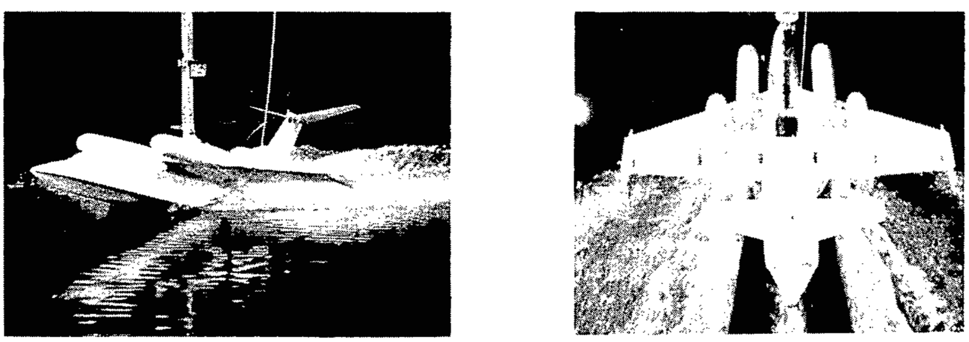
Figure 7.- Spray photographs. Flap deflection, 0°; stabilizer deflection, 0°; elevator deflection, 0°.



Trim, 9.3°; speed, 51.8 knots.

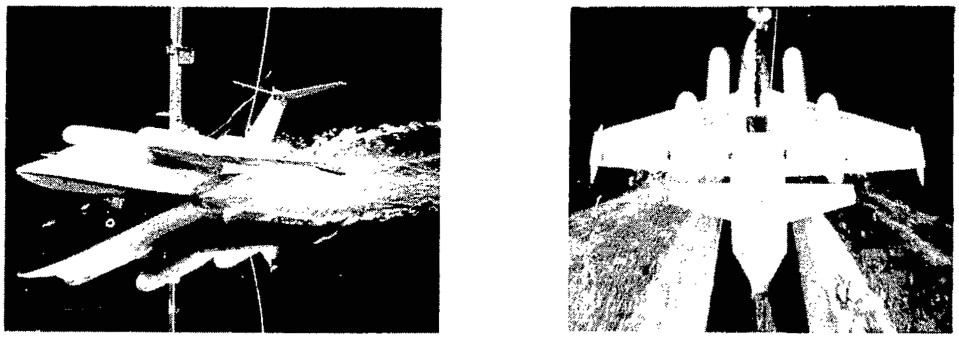


Trim, 10.0°; speed, 65.1 knots.

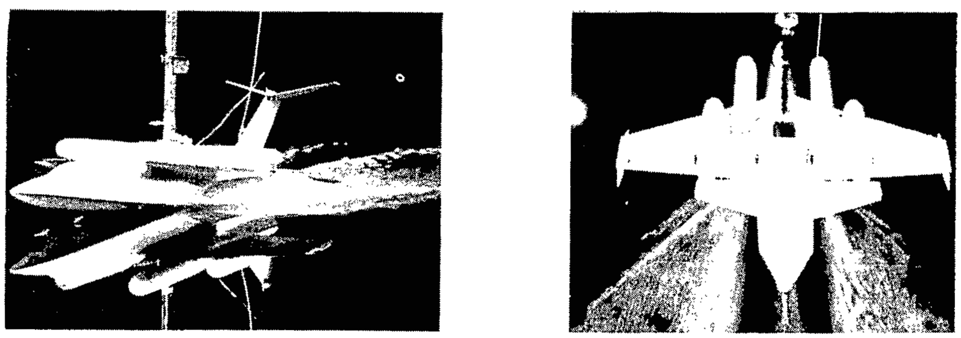


Trim, 8.5°; speed, 77.7 knots.

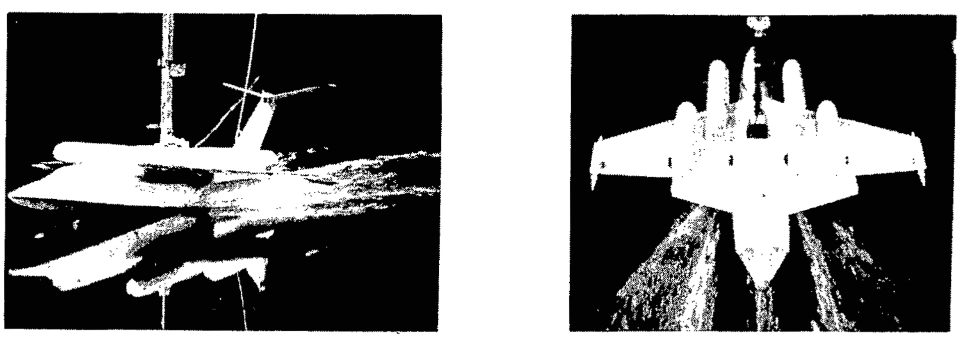
Figure 7.- Continued. L-58-1660



Trim, 5.8°; speed, 104.5 knots.

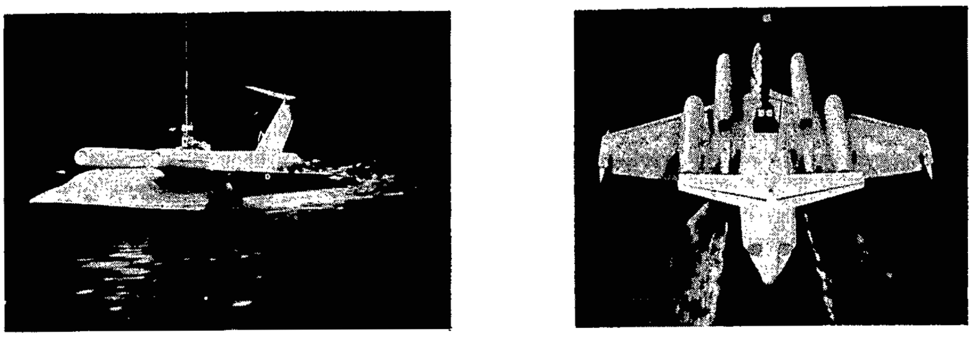


Trim, 4.5°; speed, 131.4 knots.

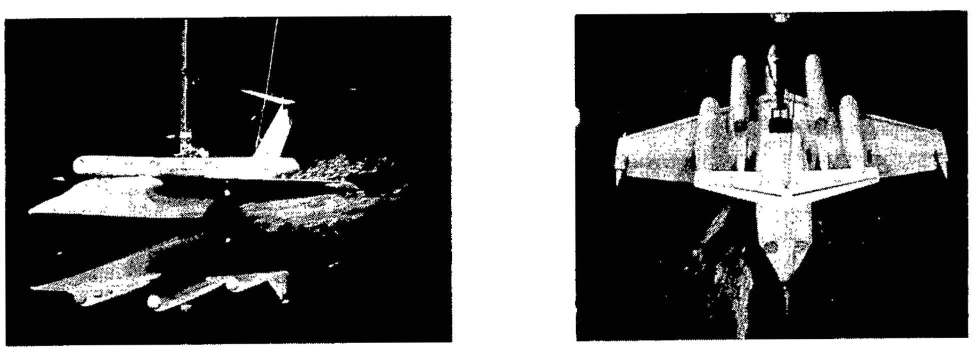


Trim, 3.9°; speed, 143.7 knots.

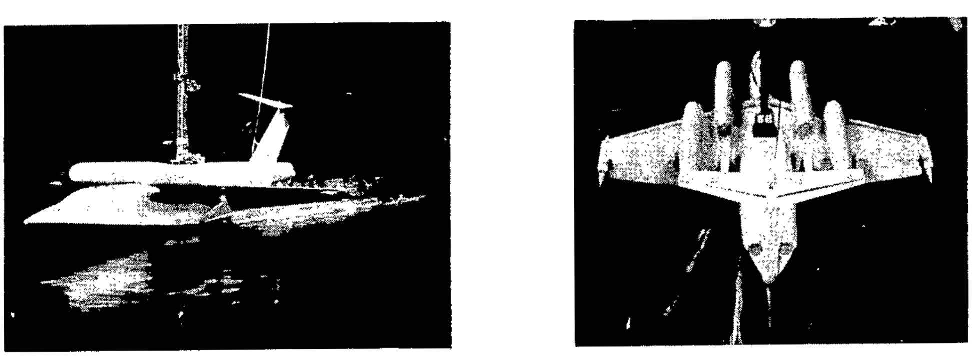
Figure 7.- Concluded. L-58-1661



Trim, 4.0°: speed, 117.7 knots.



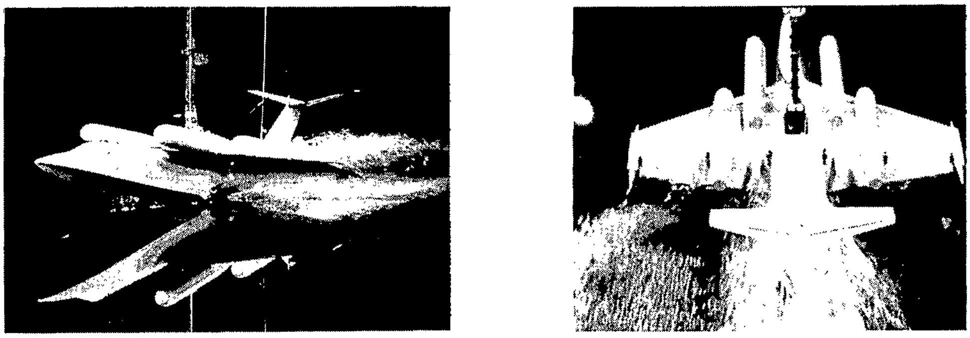
Trim, 3.2°: speed, 131.5 knots.



Trim, 3.0°; speed, 142.9 knots.

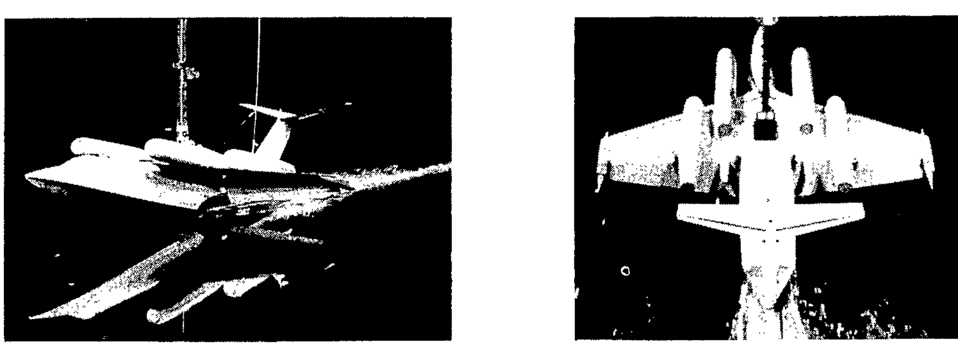
(a) Stabilizer deflection, -2.5°; elevator deflection, -5°. L-58-1662

Figure 8.- Spray photographs. Flap deflection, 45°.



Trim, 10.4°; speed, 117.7 knots.

Trim, 5.0° to 10.0° (oscillating); speed, 132.3 knots.



Trim, 7.0° to 9.5° (oscillating); speed 137.5 knots.

L-58-1663

(b) Stabilizer deflection, -6.5°; elevator deflection, -13°.

Figure 8.- Concluded.

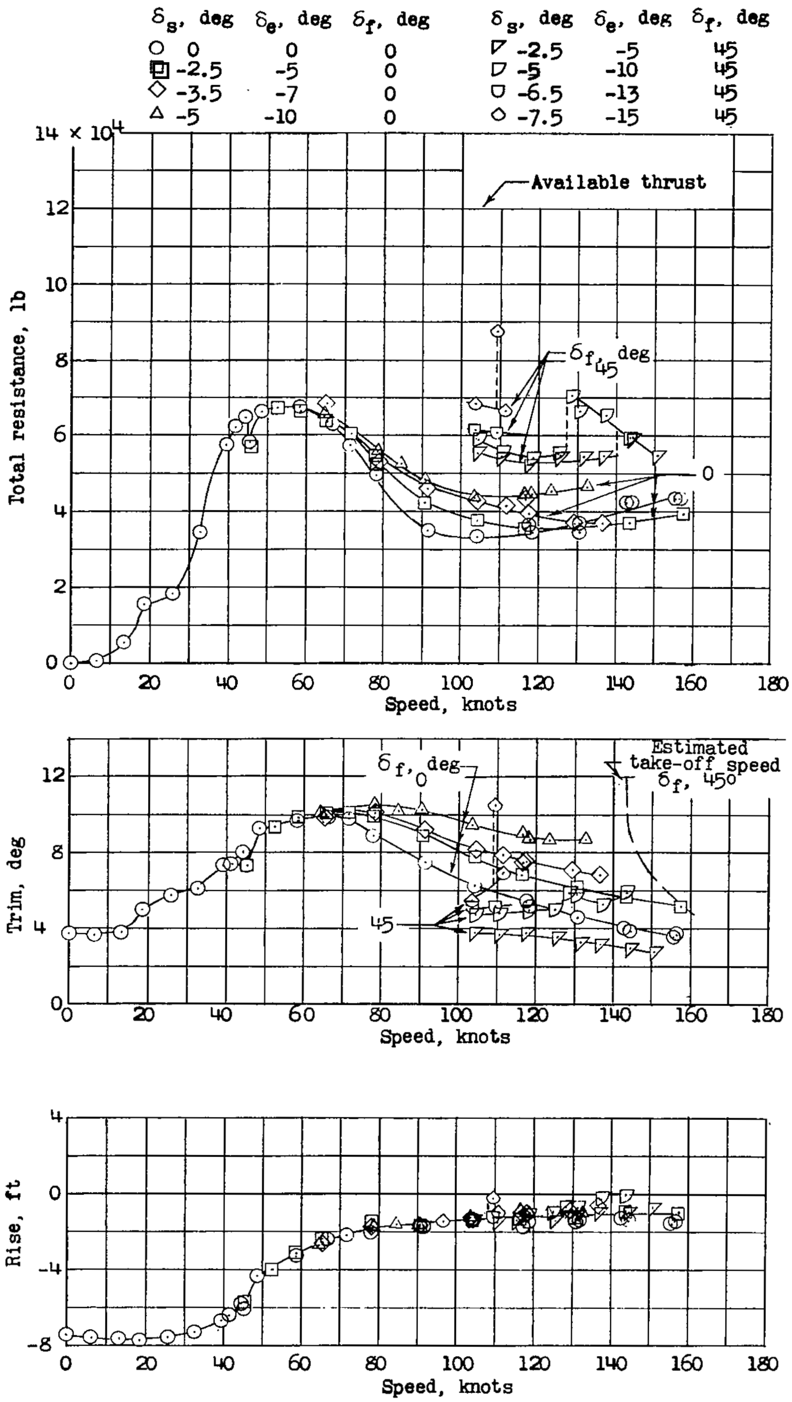


Figure 9.- Variation in total resistance, trim, and rise with speed. Flap deflection, 0° and 45°.

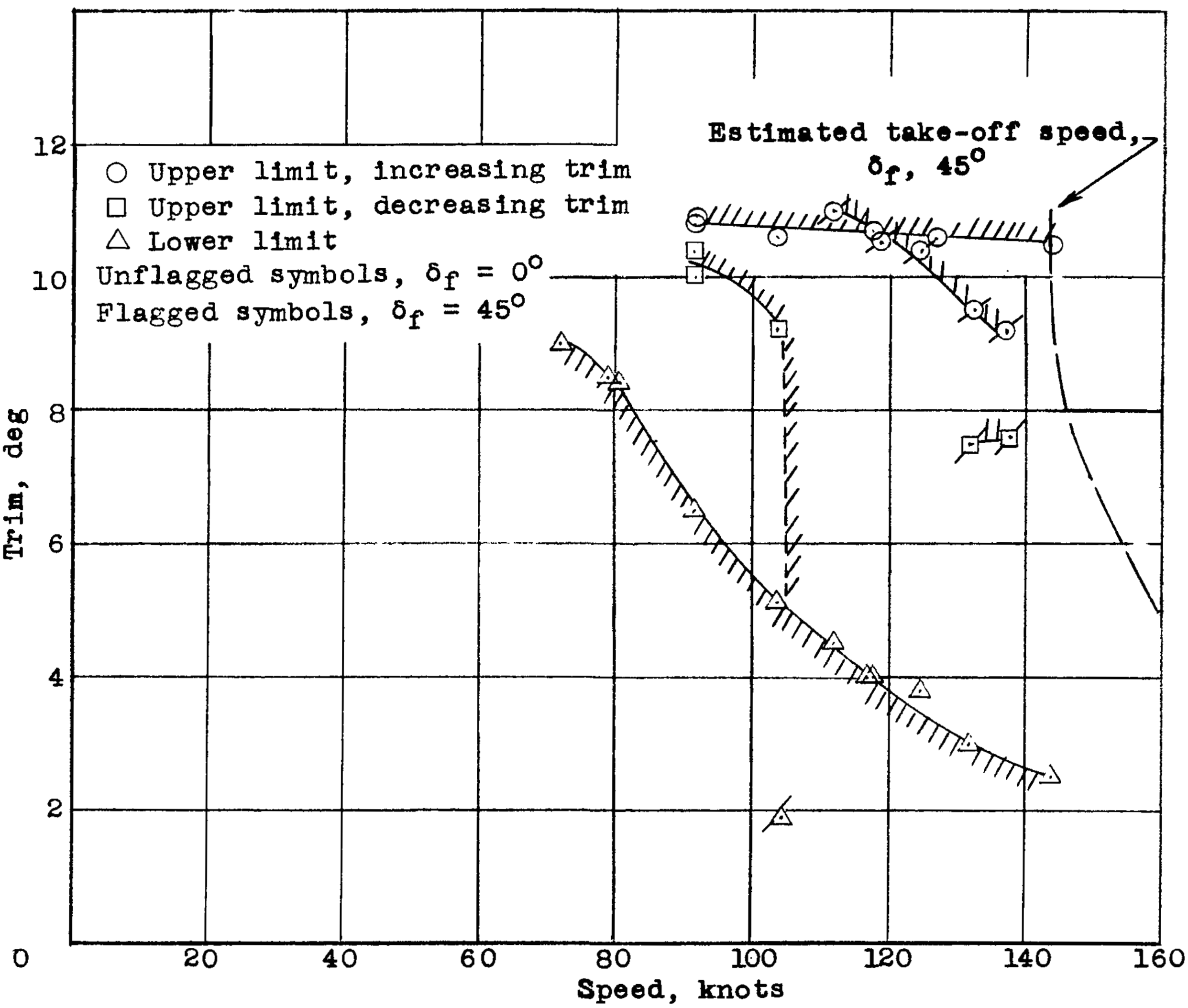


Figure 10.- Trim limits of stability. Flap deflection, 0° and 45°.

[redacted]

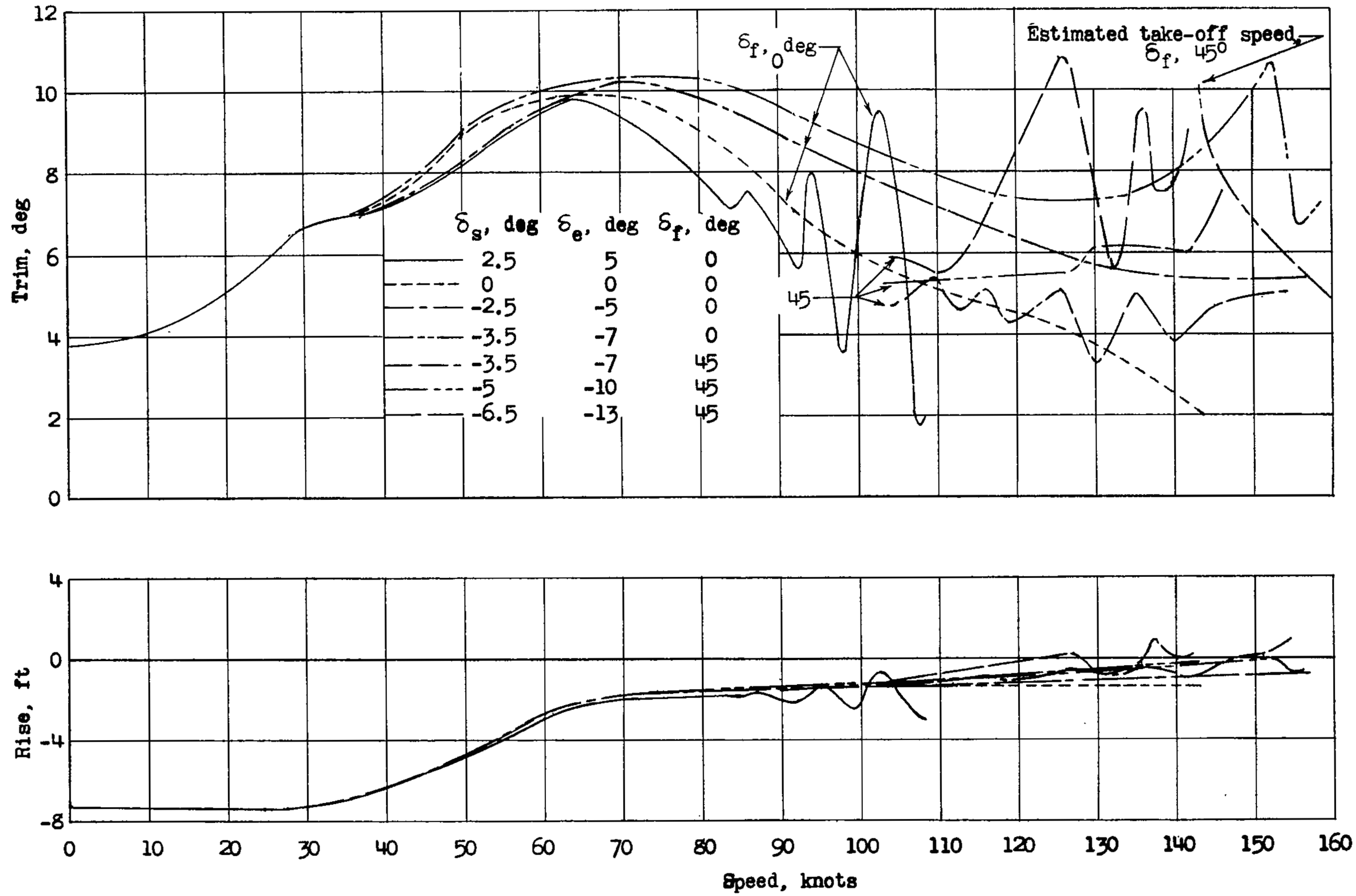
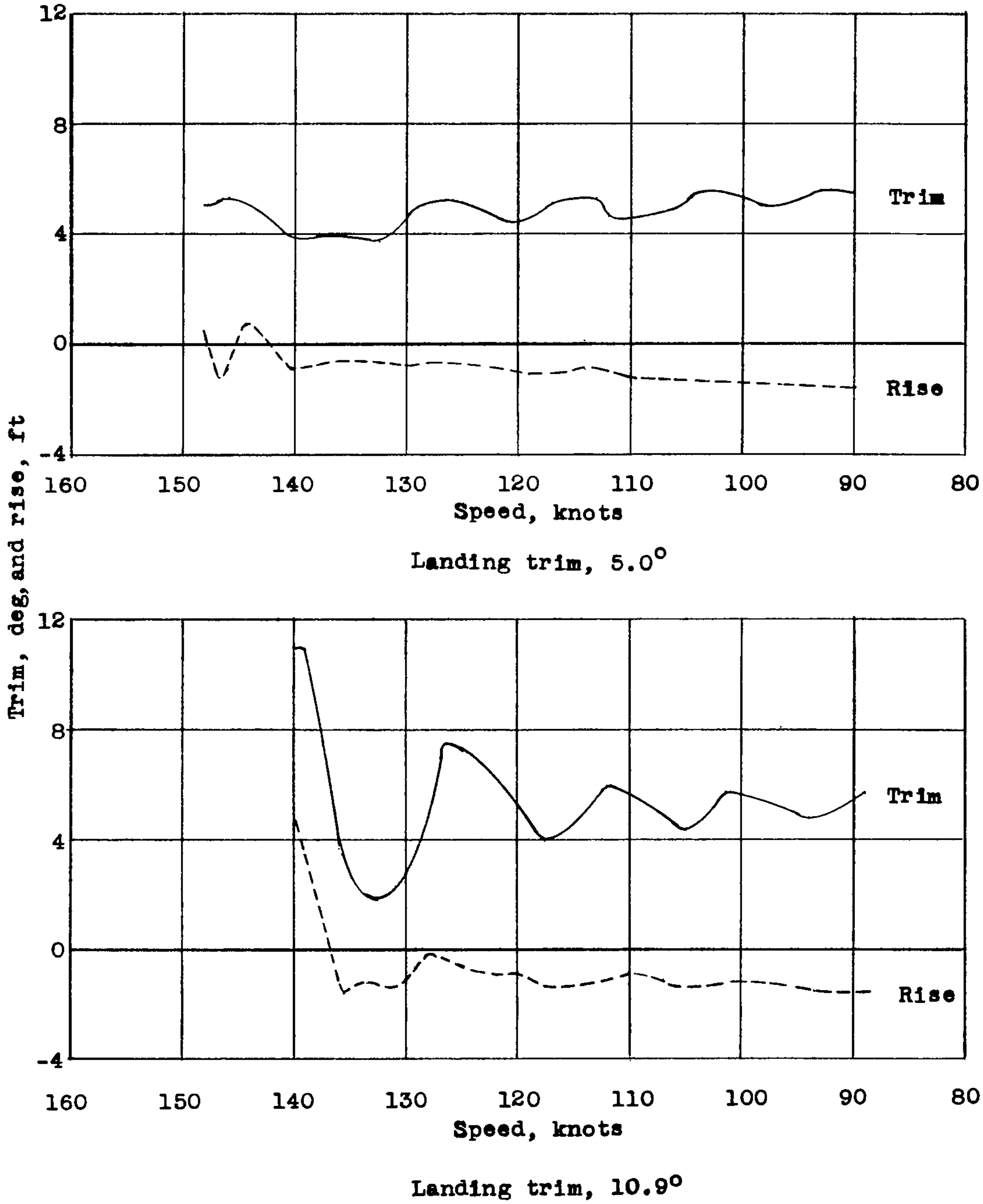
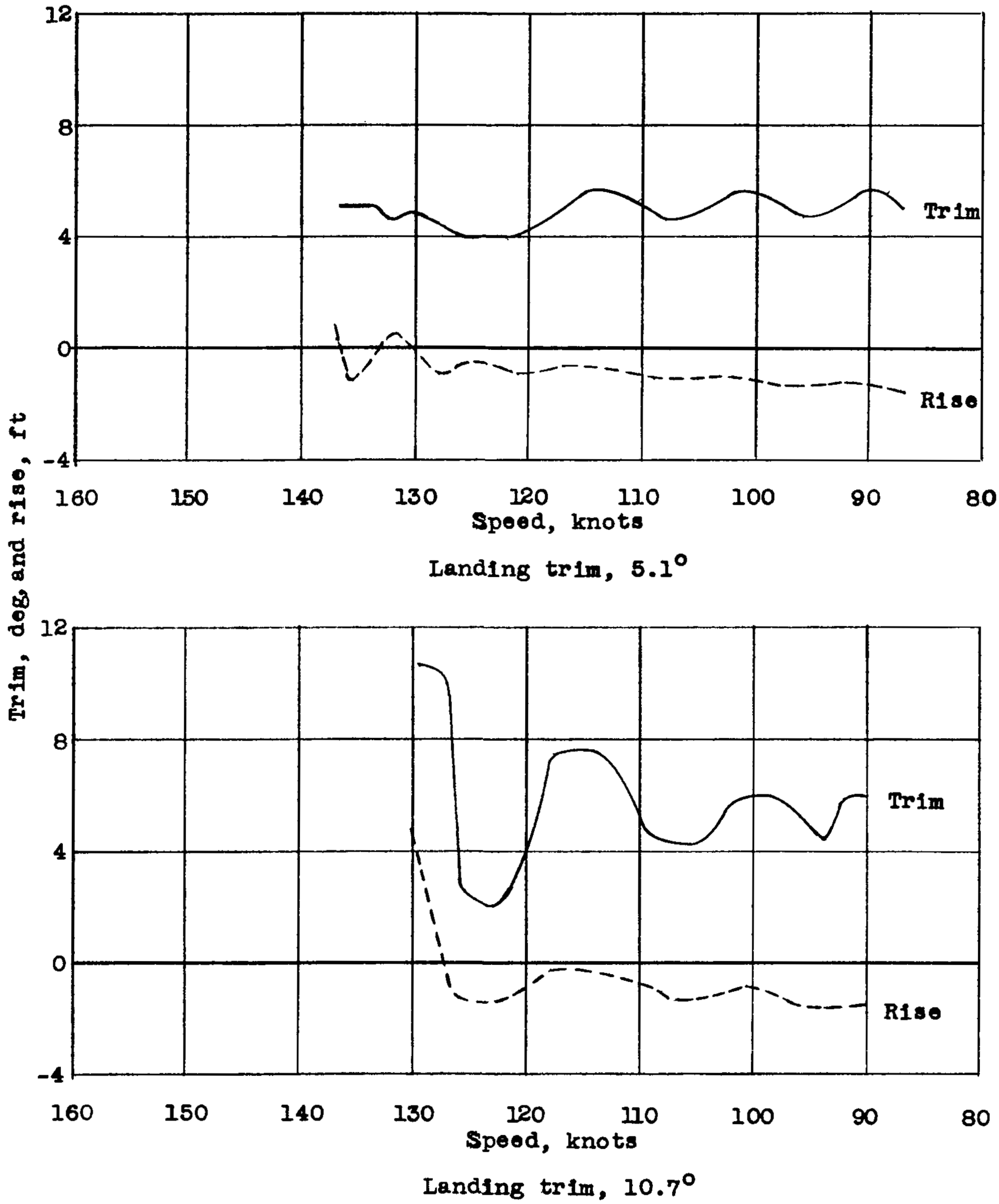


Figure 11.- Variation in trim and rise during smooth-water take-offs for various stabilizer and elevator deflections.



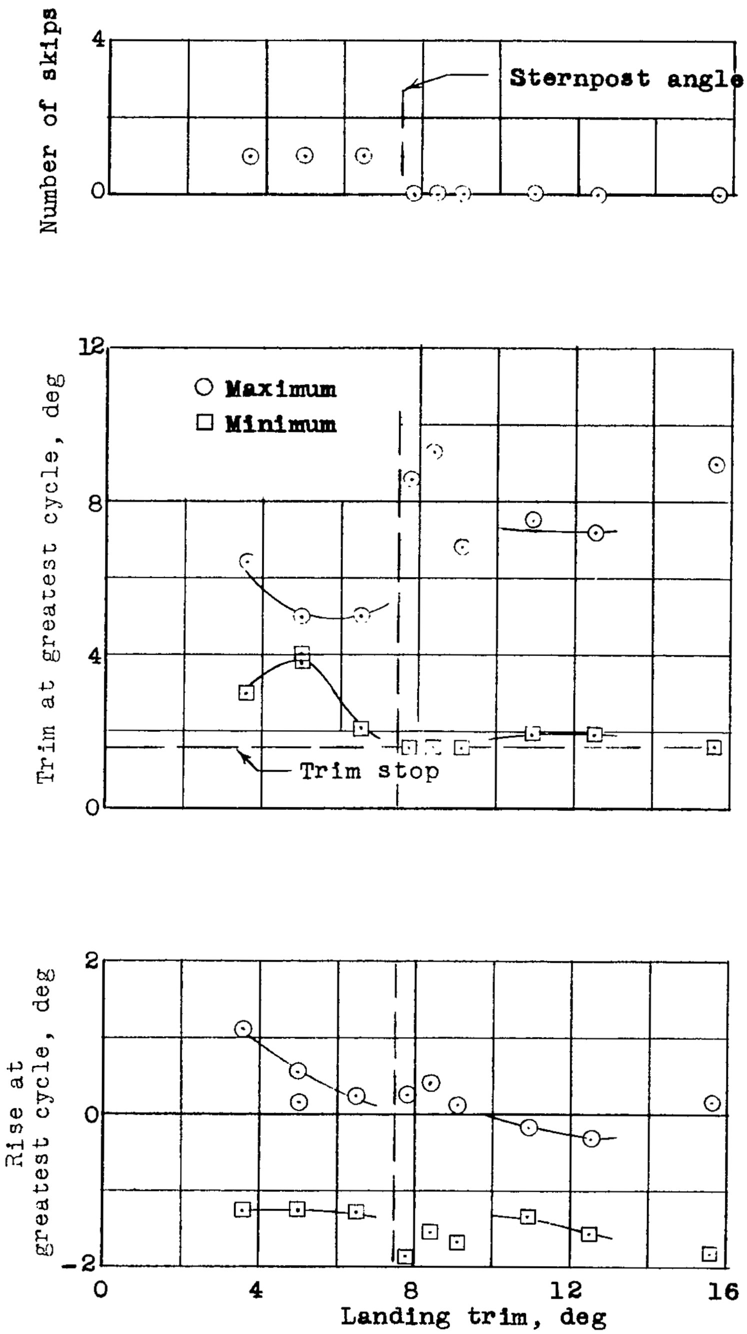
(a) Gross load, 220,000 pounds.

Figure 12.- Variation in trim and rise during typical smooth-water landings. Flap deflection, 45°.



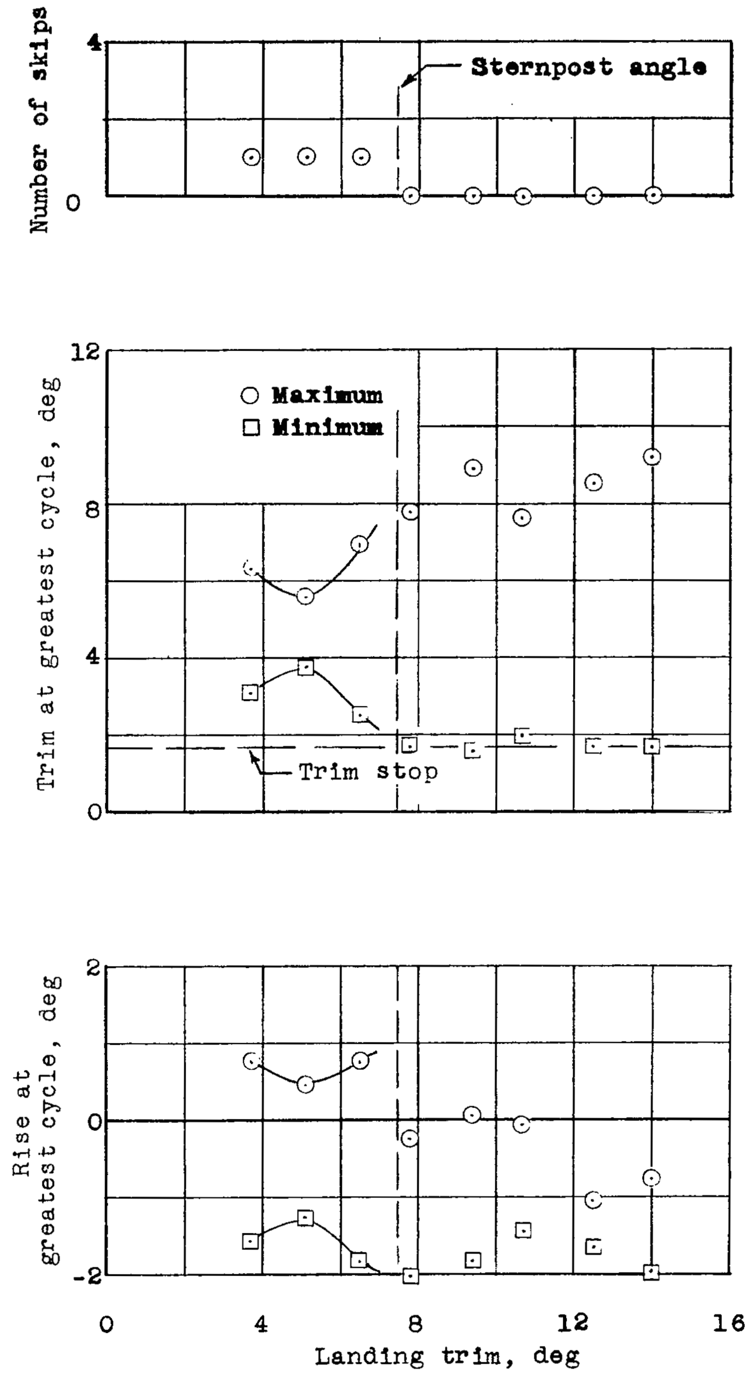
(b) Gross load, 192,000 pounds.

Figure 12.- Concluded.



(a) Gross load, 220,000 pounds.

Figure 13.- Smooth-water landing characteristics. Flap deflection, 45°.



(b) Gross load, 192,000 pounds.

Figure 13.- Concluded.

UNCLASSIFIED

UNCLASSIFIED

[redacted]